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翻　訳

Yuzu in Japan and South Korea: A Comparative Study of Usage

Nami FUKUTOME*

日本と韓国のユズ利用法の比較

福留 奈美

Summary

Yuzu (*Citrus junos Sieb. ex Tanaka*), a fruit originally from China, has been actively cultivated in both Japan and Korea in recent years. The objective of this study was to shed light on the different uses of yuzu in Japan and Korea. We investigated traditional usage of yuzu in food preparation in Japan and Korea through interviews and a study of cookbooks; investigated the main yuzu products available through market research; and analyzed differences in equipment on production lines at yuzu processing factories in yuzu-growing regions, namely Kochi in Japan and Goheung in Korea. In Japan, the main uses found were: 1) yuzu fruit juice in ponzu and seasoning; 2) fresh yuzu rind for flavoring dishes and in the spicy condiment yuzu-kosho; 3) in heated preserved foods like *yubeshi* and yuzu-miso. In Korea, 1) the main use is in the production of candied yuzu, called *yuja-cheong*; 2) *yuja-cheong* is in turn used in tea; 3) many sweets and sauces are also made from *yuja-cheong*. In Japan, the rind and juice of yuzu are usually separated and used fresh or heated. In comparison, yuzu in Korea is most commonly candied and the candied form is used in a variety of ways. It was also observed that characteristic usages have been mutually adopted by the two countries and are undergoing steady change. (This is the translation of a paper originally published in Japanese in *Dento-shokuhin no Kenkyu* (Studies of Traditional Foods), No.43, 2016).

抄　録

中国が原産の柑橘類ユズ(*Citrus junos*)は、近年、日韓での栽培が盛んに行われている。本研究では、その利用法に国ごとの食文化の違いがあると考え、日韓両国におけるユズの利用法の違いを明らかにすることを目的とした。本研究では、インタビューと料理書における料理・菓子類への伝統的な利用法と市場に流通する代表的なユズ製品について調べたほか、ユズ産地（高知県と高興郡）のユズ加工・製造ラインの比較を行った。日本での利用は主に、1）ユズ果汁のぽん酢、調味料、2）生果皮の料理や柚子胡椒、3）柚餅子や柚子味噌など加熱した保存食であった。韓国では1）ユジャチョン（ユズの砂糖漬け）への加工が主で、2）茶への二次利用、3）菓子、ソースへの二次利用が多かった。日本では、果皮と果汁を分けて生のまま、または加熱して利用することが多いのに対し、韓国ではユズの砂糖漬けとその二次利用が主流であることがわかった。また、両国でそれぞれ特徴的な利用法が相互に取り入れられ、変化している現状も観察された。（本報告は『伝統食品の研究』No.43(2016)に掲載された論文を翻訳したものである）

Keywords: usage of yuzu, comparative study, cultural differences, Japan and Korea

＊　Faculty of Health and Nutrition, Tokyo Seiei College

1. INTRODUCTION

Yuzu (*Citrus junos Siebold ex Tanaka*) originated in the upper reaches of China's Yangtze River. Japanese botanist Chozaburo Tanaka, known for his work on citrus classification, reported its existence as a remarkable wild citrus found in the provinces of Hubei, Sichuan, Yunnan, and Gansu and also in Tibet. A description of yuzu from 772 in *Chronicle of Japan, Continued* (Shoku Nihongi, published 797) suggests yuzu was already well-established in Japan in the Nara period (710-794). Yuzu undergoes asexual seed reproduction called nucellar embryony, a trait also found in other citrus fruits that can repeat indefinitely. Trees grown from such seeds are clones of the parent meaning yuzu found in Japan and Korea are genetically very close, complicating claims in botanical terms that the crop is unique to either country.

Since the 1980s, active exchange between top French chefs and mainly chefs of Kyoto kaiseki cuisine led to the introduction of yuzu on the French gastronomy scene. In addition, yuzu became known as the scent of Japan as a result of presentations by Sawamura et al. on the characteristics and efficacy of yuzu essential oil at academic conferences in Japan and abroad[3, 4]. In response to the requests of French chefs incorporating ingredients from around the world in their cuisine, the export of fresh whole yuzu from Kitagawa Village, Kochi Prefecture, to the EU began in November 2012. Nowadays, Nordic cooks also use fresh yuzu in winter dishes.

South Korea, on the other hand, produces large volumes of yuzu tea made from candied yuzu rind. Export volumes of yuzu tea increased from 10,464 tons in 2009 to 14,713 tons in 2014, of which about 90% was sent to China, Japan, Hong Kong and Taiwan. In China, where imports of yuzu tea from South Korea have increased, yuzu is said to be primarily associated with Korean yuzu tea. To date, yuzu fruit growing was almost exclusively undertaken in Japan and South Korea, but China has recently begun cultivation too.

Given the difficulty in asserting disparate regional characteristics of yuzu as a crop, this paper considers different uses stemming from distinctive food cultures and reports the results of a study focused on post-war modern times. The purpose of this study was 1) to capture the current situation and changes in yuzu cultivation in Japan and South Korea, and 2) to clarify fundamental differences in modern yuzu usage between the two countries.

2. METHOD

2.1 Comparison of Yuzu Cultivation in Japan and South Korea

Statistical data released by Japanese and South Korean ministries was checked and confirmed through direct enquiries to government agencies. Analysis of shifts in yuzu production areas and trends in South Korea was based on interviews with yuzu producers in Namhae County and Geoje City in South Gyeongsang Province, and with the director of the yuzu processing facility in Goheung County in neighboring South Jeolla Province, conducted in November 2014.

2.2 Comparison of Yuzu Usage in Japan and South Korea

Yuzu usage was examined through a literature review, primarily of modern cookbooks held at South Korea's Nongshim Co., Ltd. Library of Food Culture (Table 1 annotations), and yuzu specialty books and cookbooks of kaiseki cuisine in Japan.

This information was analyzed alongside research into yuzu products available on the market at department stores, supermarkets, convenience stores, and online sites, as well as details from interviews with food product and cooking specialists (five times total; August and November, 2014, and February, April and August, 2015).

Processing steps for key yuzu products were recorded through visits to agricultural cooperative factories in each country's most active yuzu production areas: Kochi Prefecture in Japan and South Korea's Goheung County (November 2014). Two separate visits to the home of a Seoul housewife committed to homemade products provided insight

into the cooking process for candied yuzu and traditional sweets incorporating candied yuzu (November 2014 and February 2015). Interviews with yuzu farmers took place in Geoje City and Namhae County, South Korea (December 2014), and a visit to a Geoje City yuzu processing facility enabled a comparison of raw materials in their bottled yuzu tea products. In Japan, interviews were held during a visit to a yuzu farmer in Kitagawa Village, Kochi Prefecture, and details on juice extracting equipment were recorded (February 2014). In addition, focus was placed on "yuzu tea", consumption of which has increased in Japan in recent years, and we classified domestically produced yuzu tea available through a Japanese online retail site (Amazon.co.jp as of January 2016).

3. RESULTS

3.1 Yuzu Cultivation in Japan and South Korea: Current Circumstances and Shifting Trends

Figure 1 shows the yuzu producing regions of Japan and South Korea and their respective production volumes. Figures 2 to 5 show production ratios by region for both volume and cultivation area, as well as annual trends in yields and area under cultivation.

Among the 17 first-level administrative districts of South Korea, yuzu is primarily cultivated in the southern provinces of South Jeolla, South Gyeongsang, and Jeju. Until 2004, yuzu was under cultivation in approximately ten hectares of Busan Metropolitan City, but that has decreased to less than 2 hectares since 2009. Intensive yuzu cultivation takes place in two major production areas in South Jeolla Province – Gwangyang and Wando counties. In addition to Geoje City in South Gyeongsang, Namhae Country has been known since ancient times as a yuzu production area.

In Japan, more than 80% of yuzu production takes place in three prefectures of Shikoku and two prefectures in Kyushu. In contrast to South Korea, however, commercial growing is widespread with 38 of the country's 47 prefectures yielding 1 ton or more annually, from the northern limit of Miyagi Prefecture to Kagoshima Prefecture in the south. Confirmation with local governments revealed, however, that far north Iwate Prefecture has branded their local crop "Northern Limit Yuzu", revising the northern limit for yuzu cultivation as of 2015 to Iwate Prefecture. As global warming progresses, Akita Prefecture has raised the possibility of conducting test cultivation of cold-resistant yuzu, potentially further increasing the cultivation area for yuzu in Japan.

There are two types of yuzu: a grafted variety in which a yuzu scion is grafted to the rootstock of trifoliate orange (*Citrus trifoliata* or *Poncirus trifoliata*), and seedling yuzu grown from seeds. Seedling yuzu is known for the especially long time it takes to produce fruit, as seen in a Kochi Prefecture saying: "peach and chestnut 3 years, persimmon 8 years, and the great idiot yuzu 18 years". In contrast, grafted yuzu bears fruit three to five years after grafting and has the added advantage of being easy to prune and harvest because the branches grow low and horizontally – a trait of trifoliate orange. Annual yuzu yields soared over 50 years from 19 tons in 1963 to 2,216 tons in 2012 as a result of growing demand due to high economic growth from the 1960s onwards and the spread of grafting technology. Despite stabilization of the growth rate of cultivated acreage since, yields continue to increase.

South Korea has seen an overall decline in both total yield and cultivation acreage since 2000, but in Goheung County those figures remain largely unchanged, and there have even been increases on Jeju Island. The overall falls are thought to be owing to a rapid decline in small-scale growing areas in parts of South Jeolla outside of Goheung County and in South Gyeongsang. The following is a summary of the interviews with yuzu producers in Namhae County and Geoje City, South Gyeongsang Province, and the head of the yuzu processing facility in Goheung County, South Jeolla Province.

Namhae County is a long-standing production area famous for its seedling yuzu, formerly referred to as the "university tree". Yuzu was so highly valued that one tree provided enough income to send a child to

university, and the largest trees produced over 1,000 fruits.

In the city of Geoje, east of Namhae County, yuzu growing expanded with many attracted by the high price the crop commanded about 30 years ago, but the rapid increase in yuzu growers caused prices to fall. The falling price prompted many yuzu farmers to switch to shipbuilding about 20 years ago, and then production began to decline. Over the same period, a large-scale yuzu processing facility was built in Goheung County, leading to more intensive engagement in yuzu cultivation and processing. It is said that yuzu cultivation techniques and seedlings were originally brought to Goheung from Geoje. We learned that the yuzu processing plant in Goheung is unable to produce yuzu tea fast enough to meet growing demand from China, and thus current production remains focused on yuzu tea even though there is interest in new product development.

The above findings show that yuzu has been a commercially produced crop in both Japan and South Korea over the last 40 to 50 years, and that whereas in Japan we see trends of increased production and expanded cultivation areas, South Korea is seeing continued consolidation in the key areas of cultivation.

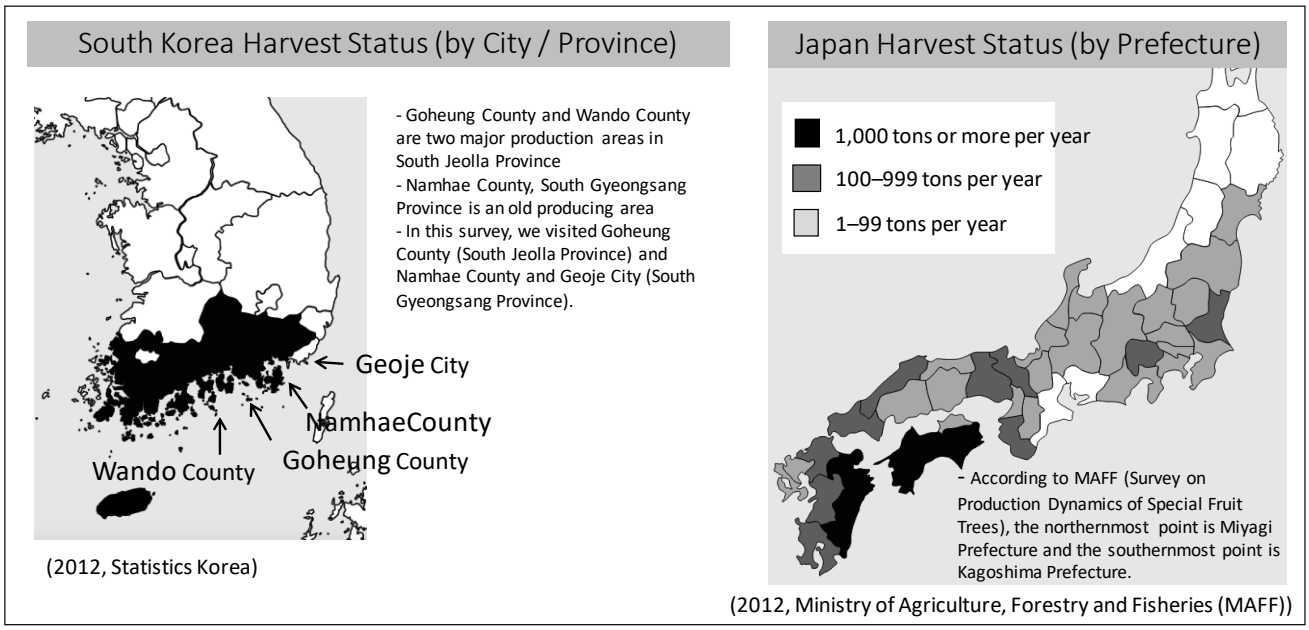

Figure 1 Yuzu Harvest Status by Region in South Korea and Japan

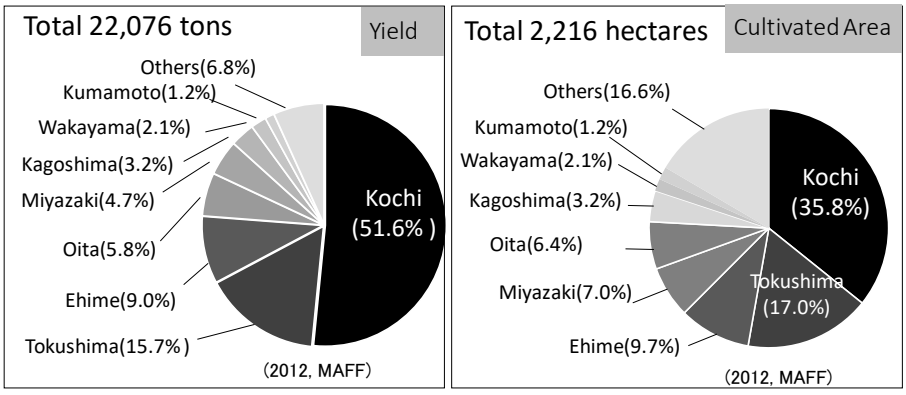

Figure 2 Japan Yuzu Yield and Cultivated Area Ratios by Prefecture

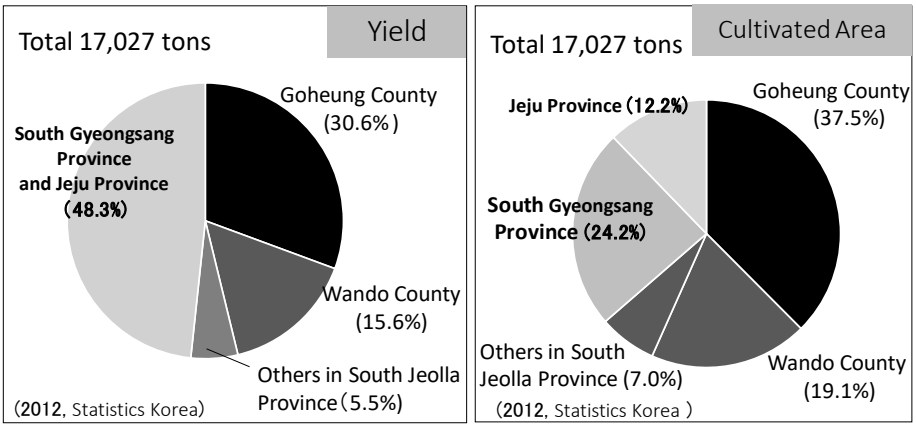

Figure 3 South Korea Yuzu Yield and Cultivated Area Ratios by Region

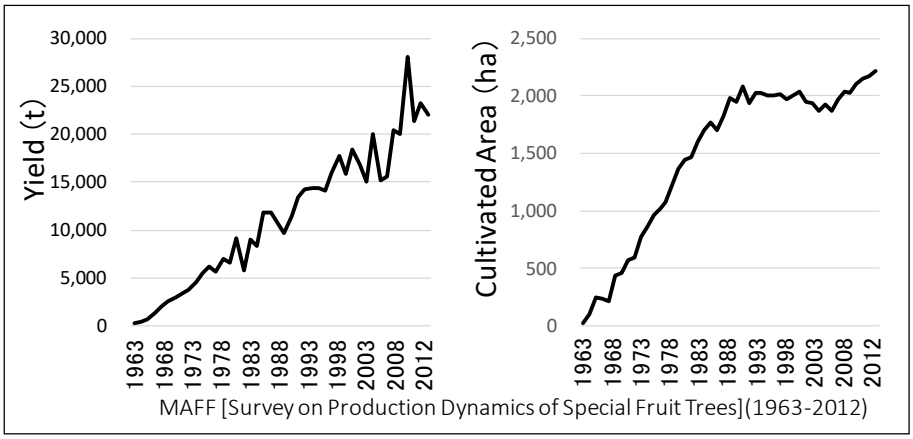

Figure 4 Annual Change in Yuzu Yield and Cultivated Area in Japan

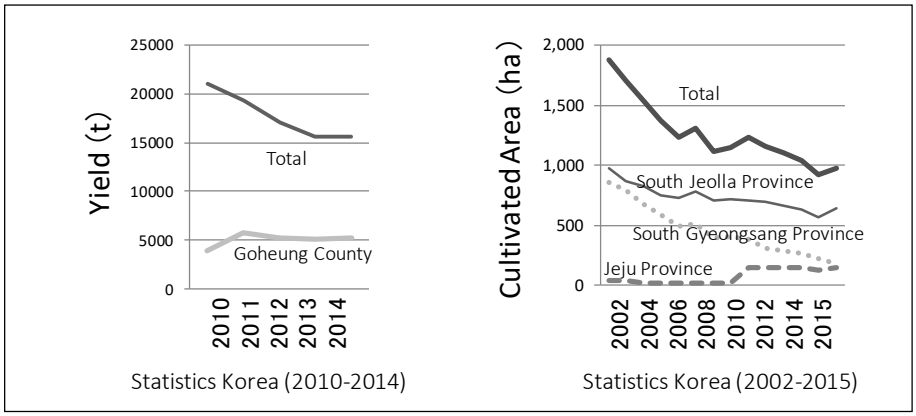

Figure 5 Annual Change in Yuzu Yield and Cultivated Area in South Korea

3.2 Traditional Uses for Yuzu in Japan and South Korea

3.2.1 Traditional Korean Recipes for Yuzu From Cookbooks

As shown in Table 1, apart from the use of strips of raw outer rind (flavedo) in the *yuja-hwa-chae* drink, there is very little use of raw yuzu rind in South Korea; in most cases the rind has already been processed in some way as in *yuja-cheong* (yuzu candied in sugar or honey).

Though strips of candied yuzu are the most common type nowadays, various traditional methods for making *yuja-cheong* involved preserving the whole fruit, cutting the outer rind into large pieces for

candying, or stuffing the rind and tying with thread to maintain the round shape during preservation.

Yuja-hwa-chae and *wonsobyeong* are classified as traditional beverages using syrup-preserved ingredients, and were once elaborate products reserved for high-ranking people. In many cookbooks, *yuja-hwa-chae* recipes called for raw yuzu rind, but according to a renowned researcher of Korean food culture, Yun Seo-seok, it is also possible to cut just the yellow outer rind into large pieces and preserve them in sugar for *yuja-hwa-chae*. Sugar or honey-candied yuzu can be used for either the resulting syrup, as in *tenjachon* (honey-preserved trifoliate orange pulp), or for the solid peel. The solid component is sometimes used as filling in mochi-style confectionery, or for coloring and flavoring in the same way as sesame or mugwort. Present-day recipes for *yugwa*, deep-fried rice puffs coated with various toppings, do not call for *yuja-cheong*, but in the past the *yuja-cheong* syrup was used to bind the coating. We can see that in South Korea there has long been a culture of using sugar- and honey-candied fruits in various ways.

3.2.2 Yuzu Usage in Japan by Fruit Part

As shown in Table 2, in Japan, we can see various examples of yuzu usage, including applications of just the outer skin, the whole skin, both the skin and the pulp, and the juice. Examples of use in Western-style confectionery are also included, but it is clear that there has been widespread use of yuzu across kaiseki cuisine, regional cooking, and home cooking in Japan since ancient times.

i) Flavedo Uses

One distinctively Japanese tradition is the use of raw yuzu rind to flavor or add aroma to dishes. In Japanese cuisine, raw flavedo rind shaved with a knife is floated in soup as a fragrant garnish. The different cuts of yuzu rind have names based on their shape (Table 2), and slight variations are all accounted for in detailed names like *kizami-yuzu* (shredded yuzu) and *hari-yuzu* (needle-like yuzu), *ore-matsuba-yuzu* (bent pine needle yuzu) and *sanbon-matsuba-yuzu* (triple pine needle yuzu). In addition, the method of sprinkling finely grated yuzu rind, called *furi-yuzu*, is applied to flavor a wide range of simmered, steamed, and grilled dishes, as well as in noodles, soups, dressings, vinegared dishes and pickles. Rind is also found in Japanese sweets in the form of *yuzu-an,* yuzu-flavored sweet bean pastes, and *yuzu-mochi* glutinous rice cakes. It is custom in Japan to enjoy the aroma of yuzu over a long season from the quintessential summer ingredient green yuzu found in soups and as *furi-yuzu*, right through until the fruit turns yellow. In contrast, green yuzu is not used in South Korea. When yellow yuzu is in season in Japan, *sarashina soba* restaurants make *yuzu-kiri* by kneading yuzu flavedo into the noodle dough. Yuzu miso – one type of *name-miso* eaten straight – is made as a side dish for rice or used as *dengaku-miso* to top grilled ingredients.

ii)Whole Yuzu Rind Uses

One method using the whole pericarp called *yuzu-gama* or *yu-gama*, means yuzu pot. A small carved out yuzu is used as a bowl and filled with ingredients like *kohaku-namasu* vinegared white radish and red carrot for Osechi new year's celebratory dishes, or as the vessel for steaming ingredients. Variations in presentation include yuzu pots with leaves still intact, decorative carving of the lid to look like a chrysanthemum, and green yuzu cut into three large pieces to mimic the splitting of Japanese *sansho* pepper buds known as *wari-zansho*.

Large yuzu pots are used to make *maru-yubeshi*, a traditional steamed yuzu dumpling unique to Japan. Nakai[17] and Ito et al.[18] have reported on their research into *yubeshi*, detailing regional and historical differences in production methods.

One method for sweet-simmered yuzu rind is often found in *hassun*, a dish served with sake in *cha-kaiseki* tea ceremony kaiseki cuisine. Chef Koichiro Goto of Ryuun-an *cha-kaiseki* restaurant in Shinjuku shared his method with us (Table 3). The recipe is almost identical to that for *Amigasa-Yuzu* – sweet-simmered yuzu rind shaped like traditional straw hats – found in one cookbook referenced in our research[13].

Table 1. Yuzu in Traditional Confectionery and Beverages in Korea

Candied with sugar and/or honey
***Yuja-cheong*:**
Made by traditional methods also used with honey-candied trifoliate orange and other fruits, such as punching holes from outside with chopsticks, and alternating layers of sugar and fruit in a glass jar for candying*10. Divide fruit into four equal parts and remove thin white part of rind before preserving in sugar to ensure resulting juice is transparent*10.
***Yuja-cheong* - whole type:**
A traditional method using the whole rind. A sugar-dusted paste of julienned chestnuts, jujube fruit, and rock tripe lichen is wrapped in yuzu rind and preserved in honey water*5-7. Another recipe calls for yuzu rind to be blanched in boiling water and divided into 6 to 8 pieces. Combine yuzu pulp with sugar and julienned jujubes, chestnut, and mushrooms, return the mixture into the rind, tie it with a thread and preserve in sugar water *10.
***Yuja-cheong* - julienne type**
Most common modern method. Pulp is removed from the fruit; rind is julienned and candied. In home recipes, julienned raw rind and chopped pulp are often preserved together in sugar and honey*1, 2, 12.
Traditional beverages
Sweet beverages : *Hwa-chae*
Traditional punch containing cut fruit, edible flowers and other ingredients in a liquid of sugar water, honey water or cordial flavored with *omija* (Schisandra fruit/ magnolia berry). Raw or candied pears, strawberries, peaches, plums, watermelons, yuzu, and other fruits are used. The yuzu variety includes raw outer rind (flavedo), julienned pear, pomegranate, pine nuts and other ingredients*1,3-6,7. Another style includes plentiful yuzu flavedo strips, that have been candied in an equal amount of sugar, floating in either sugar water or omija water*10.
Sweet beverage with dumplings : *Wonsobyeong*
Sugar or honey water beverage containing dumplings of boiled glutinous rice flour mixed with jujubes or yuzu rind* 5. Traditionally served to high-ranking people after meals or instead of tea*11. Yuzu variety uses syrup of *yuja-cheong**1,6, solid part of *yuja-cheong**4, or raw yuzu rind*1,3.
Yuja-cha
Drink of *yuja-cheong* (yuzu candied in sugar or honey) mixed in hot water. The processed and bottled *yuja-cheong* sweet paste may also be referred to as *yuja-cha* *13. Sometimes the julienne type *yuja-cheong* is called *yuja-cha* to distinguish it from the whole type *yuja-cheong**5.
Traditional Confectionery
Yugwa*: *Gangjeong
Glutinous rice flour that has been moistened with alcohol and steamed is kneaded well and spread flat before being cut and dried in the shade. It is then deep-fried twice in oil, coated with honey, and dusted with various toppings (sesame, pine nuts, cinnamon)*9. *Gangjeong* is the name for the thin rectangular shape of the confection. The syrup of *yuja-cheong* is sometimes used instead of honey*2,10.
Deep-fried Confectionery: *Ssal-gangjeong*
Rice confectionery of boiled and dried ordinary rice that is deep fried and hardened by coating with a boiled down syrup of glucose syrup, sugar and a little salt*12. The yuzu variety called *yuja-gangjeong* adds *yuja-cheong* to the syrup used for coating*12. In some cases, only the solid portion of *yuja-cheong* is used.
Steamed rice cake: *Sourgi*, *sourgi-tteok*
Rice cake made from steamed non-glutinous rice flour*9. In addition to white *sourgi* made only from rice flour and sugar, other types include black beans, azuki beans, mugwort, and others*8. Yuzu referred to in a *yuja-sourgi* recipe *2 is thought to be *yuja-cheong**11.
Steamed rice cake with solid ingredients: *Duteop-tteok*
Glutinous rice flour combined with *ganjang* (Korean soy sauce), honey, and other ingredients, and filled with yuzu, pine nuts, or azuki bean paste before steaming*8. Yuzu in these recipes is thought to indicate *yuja-cheong**11.
Steamed rice cake: *Japgwabyeong*
Sugar, chestnuts, jujubes, dried persimmon, walnuts, the solid portion of *yuja-cheong*, and other ingredients are added to non-glutinous rice flour. The mixture is steamed and cut into squares *1
Boiled confectionery: *Jeonggwa*
Generic name for fruits and vegetable roots and stems stewed with honey, glucose syrup, and sugar*5. *Yuja-jeonggwa* is prepared by stewing candied yuzu rind strips in sugar or honey*10, or by drying sugar-candied yuzu rind* 2.

*1 Park Ojin, Kim Young Sun, Jeong Pyobeom Choe, Mun Hwi Bun, 2007, *Hangug-ui Tteog, Eumlyosu-lyu* (Korean Rice Cakes and Drinks), Hunmin-sa, Seoul, pp 34,76, 212, 236, 238.

*2 Che Seun Jya, 2003, *Jayeon-ui Eunhyeleul Dam-eun Mas-issneun Eumlyo* (Delicious Drinks Filled with Nature's Goodness), Hangug Oesig Jeongbo Jusighoesa, Seoul, pp 17,25,120.

*3 Jusighoesa Julo Chingu, 1983, *Jubu Saenghwal Kadeu Yoli* ⑱ (*Tteog · Hangwa · Hangug Yoli Eumlyo* (Housewife Living Cooking Cards 18: Rice Cakes, Korean Sweets, Korean Dishes and Drinks), Seoul, pp 28,31.

*4 Gang-In Ji, 1987, *Hangug-ui Mas* (Korean Taste), Daehan Gyogwaseo Jusighoesa, Seoul, pp 344,346.

*5 Kim Dok Ki, 2006, *Tteog, Hangwa, Eumlyosu-lyu (*Rice Cakes, Korean Sweets and Drinks), Silakawa Chulpansa, Seoul, pp 329,331,333.

*6 Kim Hae Yeong, 2002, *Hangug-ui Eumlyosu-lyu* (Korean Drinks), Doseo Chulpan Hyoilu, Seoul, pp 176,224.

*7 Library of Food Culture, NONGSHIM Food Culture Research, web-site: www.agroheartco.kr/arg/culture/season_lst.jsp

*8 Cheong Eun Saeg, 2005, *Korean Cooking Glossary to Make Eating Tours More Fun*, Nihon Keizai Shinbunsha, Tokyo, pp 232-252.

*9 Yun Seo Seog, 1995, *Korean Food Culture History*, Domesu Publishers Inc., Tokyo, pp 41-48, 94-100.

*10 Interview with Dr. Yun Seo Seog, Seoul, November 2014.

*11 Interview with Ms. Li Lin Hwa, Seoul, November 2014, and February and April 2015.

*12 From the production process of Ms. Kim Bok Kyum (Seoul resident), November 2014.

*13 From the manufacturing process of the Goheung County Agricultural Cooperative Yuzu Processing Plant, November 2013.

Table 2. Japan Yuzu Usage by Part

As a flavoring in soup*1; to finish simmered foods, grilled foods and steamed foods; as a topping/garnish on noodles (*udon* etc.) and *chirashi-sushi*; in vinegared dishes and dressed vegetables dishes; in vinegared miso; in pickles (*yuzu daikon* etc.); incorporated into *soba* noodle dough; *mochi* sticky rice cakes (*yuzu-mochi*); yuzu flavored sauce; yuzu-flavored miso.
Pericarp (flavedo and albedo)
As a serving pot *(yuzu-gama)**2; yuzu dumpling(*maru-yubeshi)*; yuzu-kosho chili pepper paste; soy sauce-pickled *tsukuda-ni*; candied in sugar or syrup; simmered yuzu; to flavor pickled vegetables (*ni-namasu*); sugar candied; peels; glace; in powdered dried foods such as seven spice mix *yuzu-shichimi ;* dried peel in yuzu tea with tea leaves.
Rind and pulp
Sauces (*yuko-yaki, yuan-yaki); steamed dishes (yuko-mushi);* marmalade and jam; noodles; whole yuzu paste (*yuzu-neri*); Korean-style yuzu tea.
Fruit juice
- As vinegar substitute
In vinegared rice and vinegared dishes; dipping soy sauce for sashimi; in vinegared soy sauce and vinegar/soy sauce/ sugar mixes; vinegared miso; dressings.
- As citrus juice (incl. some pulp use)
100% fresh juice; *yuzu-ponzu*; yuzu yokan gelled bean paste; juices and alcoholic beverages; sauces and syrups (e.g. for shaved ice); ice cream and sherbet; jelly and mousse; chocolate, gummi candy and hard candy; other sweets; as a lemon substitute.
Other than food, also used in lotions (seed), and for baths (whole fruit), etc.
*1 In addition to grated *furi-yuzu*, various decorative cuts are used and each named according to its shape, incl. *kizami-yuzu* (finely carved), *hari-yuzu* (needle-like), *naga-yuzu* (long), *matsuba-yuzu* (pine leaves-like), *ore-matsuba-yuzu* (bent pine leaves-like), *sanbon-matsuba-yuzu* (three pine leaves-like), *hegi-yuzu* (thinly peeled), *mangetsu-yuzu* (full moon-like), *kake-yuzu* (waning moon-like), *hanabira-yuzu* (flower petal-like), *momiji-yuzu* (maple leaf-like), *shikishi-yuzu* (square paper card-like), *tsumagata-yuzu* (sashimi garnish-like), *tanzaku-yuzu* (thin strip), etc.
*2 Several variations of *yuzu-gama* exist such as *hatsuki-yuzu-gama* (with leaf), *yuzu-no-kiku-gama* (with chrysanthemum), *aoyuzu-no-warizansho-gama* (green yuzu with sansho pepper), etc.

Table 3. Recipe for *Yuzu-amani*, sweet-simmered yuzu

1) Gently grate the outside of the outer rind to remove bitterness and discard. 2) Peel the rind, cut into bite-sized pieces, and boil in water for about 5 minutes. 3) Soak in water to remove bitterness for half a day to a whole day. 4) Combine equal parts water and sugar and bring to boil to make a syrup. Add rind from 3 and simmer. 5) After simmering a little, turn off the heat and allow flavor to permeate fully. Suitable for long-term storage if boiled down.

A seasoning paste of finely grated yuzu rind, green chili peppers and salt called *yuzu-kosho* originated in Oita Prefecture. It has gained nationwide popularity in recent years and new versions made with yellow yuzu and peppers or red chili peppers have appeared in addition to the standard green type. Green *yuzu-kosho* can only be made from August to September when green chili peppers and green yuzu are in season concurrently, thus it is stored for use year-round. In the Kyushu region especially, it is often served as a condiment for soups and hot pots, as well as for grilled and steamed dishes such as *yakitori* grilled chicken. These days, *yuzu-kosho* is also exported to the United States and is marketed as a distinctively Japanese seasoning.

At a taste workshop conducted by the author at NYCAS2016 (New York Conference on Asian Studies, Vassar University)[19] introducing dashi products, Japanese tea, miso, soy sauce and *shichimi* seven spice seasoning, yuzu products (*maru-yubeshi*, yuzu mochi, rind, and *yuzu-kosho)* were especially well-received, and many participants listed yuzu as their ingredient of particular interest.

iii) Combined Rind and Pulp Uses

In *Yuan-yaki*, a Japanese grilled dish, equal parts of yuzu fruit round slices, soy sauce, mirin, and sake are combined in a marinade to flavor raw fish fillets. *Yuko-mushi* is a dish in which yuzu fragrance is transferred by steaming the main ingredient topped with yuzu slices. *Yuzu-neri* is a preserved food made by cooking whole fruit until it collapses before kneading and mixing with glucose syrup.

iv) Fruit Juice Uses

There are two main uses for yuzu fruit juice: as a substitute for vinegar, and instead of lemon where citrus juice is called for, particularly when a highly acidic and fragrant juice, or *kosan-kankitsu*, is desired.

In Kochi Prefecture, Japan's largest yuzu growing area, many families plant one or two trees of *kosan-kankitsu* (called *su-mikan* vinegar oranges in Kochi) in their gardens and use the high acid fruit juice as a vinegar substitute. The sushi rice in well-known local dishes *Inaka-zushi* (countryside sushi) and *Saba-zushi* (whole mackerel sushi) is often made with yuzu juice instead of sushi vinegar (Figure 6). If you visit daily street markets, such as a Sunday market, yuzu juice is available throughout the year. Before refrigeration, 1800 milliliter bottles of yuzu juice were preserved by adding salt in a ratio of 10 to 20 percent, and bottles were buried underground in valleys to ensure year-round usability. The juice of seedling yuzu fruit is recognized as especially valuable given its stronger fragrance compared to grafted yuzu.

The most typical application of yuzu juice is in ponzu – a tangy soy sauce–based seasoning. Ponzu

Yuzu juice pressed by a farmer

In the days before refrigeration, salt was added, but now salt-free juices are mainstream. Special markings made on juice products from seedling yuzu fruit.

Sushi using yuzu juice

In addition to vegetable sushi, yuzu juice is used in sushi of vinegared fish like mackerel, horse mackerel, hairtail, and Japanese goatfish (photo at Sunday market, Kochi City)

Figure 6 Yuzu Juice Sales in Kochi Prefecture

was originally made with juice from especially succulent *daidai* bitter orange fruit and served at restaurants specializing in pufferfish hot pots. In recent years, many bottled products incorporating yuzu juice can be found with the name *yuzu-ponzu*. A survey at a Tokyo grocery store (November 2014) revealed that of a total of 38 ponzu items stocked, 14 included "yuzu" in their product names; 10 included other citrus varieties (*sudachi* 2, *daidai* 3, *kabosu* l, lemon 1, *shikuwasa* 2, *dekopon* 1); and a further 14 types contained no citrus name, showing the popularity of the *yuzu-ponzu* style.

Yuzu fruit juice is often used in juices, alcoholic drinks and other beverages, and is also widely used in Western sweets such as ice cream, sherbet, and jelly. Traditionally, yuzu fruit juice and/or finely grated flavedo rind has been used to make a gelled confection called *yuzu-yokan*.

3.3 Production of Main Processed Yuzu Goods in Japan and Korea

3.3.1 Main Korean Processed Yuzu Goods – Yuja-cheong Production

i) At a Yuzu Processing Plant

In Korea, the target product is sugar-candied rind (*yuja-cheong*), thus the juice is a by-product mainly exported to Japan. Fresh yuzu fruit is delivered to the facility and the stalk and black spots on the outer rind are manually removed. This process is not conducted in Japan but it is essential in Korea where yuzu rind is the key component. The yuzu are washed, drained, and put on a conveyor to be halved and pressed to separate pulp and seeds from the rind through a drum type separator. Any seeds and flesh still attached to the rind are manually removed before the rind is sent through a special cutting machine – another process unique to *yuja-cheong* in Korea. The julienned strips of rind are weighed and mixed well with an equal amount of sugar before bagging. A lot of manual work is required to ensure high-quality rind, and this need for human input is a distinguishing feature of the Korean process (Figure 7).

ii) Making Yuja-cheong at Home

As shown in Figure 8, homemade *yuja-cheong* differs from factory-made products in that it includes not only rind but also yuzu flesh. In the home where our photo shoot took place, the method was handed down from mother to daughter. The yuzu, ordered

from Goheung County at a cost of 65,000 won per 10 kg (approximately 6,900 yen as of November 2014), was used in its entirety to make the most of the purchase without waste. Because the flesh increases sourness in the resulting *yuja-cheong*, sugar and honey are added in a slightly higher ratio (8 kg total) than the fresh yuzu itself, 8 kg of which yields 7 kg of rind and flesh.

Listening to the Korean family talk, I learned that Korean-made and in particular homemade *yuja-cheong* is very highly valued. Although it takes time and effort, the homemade variety is totally different to commercially available bottled *yuja-cha*. In addition to use in yuzu tea just by adding hot water, it can be used as is in traditional rice confectionery *ssal-ganjeong* (see Table 1), and the syrup can be mixed with ganjang (Korean soy sauce) to make sauces in cooking. In the room next to the kitchen, alongside a large kimchi refrigerator stands a food storage shelf filled with bottles of various fermented seasonings, pickles, and sugar- or honey-candied fruits and vegetables such as trifoliate orange, plums and ginseng. The trifoliate orange fruit is far too bitter to be edible, but the syrup has various applications. In contrast, *yuja-cheong* proves more efficient as there are uses for both the solid and syrup components.

Yuzu fruit fills the Seoul fruit and vegetable market from November to early December but is not available anywhere outside that season. The situation in Japan is very different, with green yuzu available from summer. And right through December, fresh yuzu fruit is widely distributed to meet demand for yuzu baths at the winter solstice and for New Year celebrations. Even outside this extended season, yuzu can be found commercially for use at department stores and in restaurants to flavor dishes. The above shows clear differences between Japan and Korea not only in usage and application of yuzu but also in seasonality.

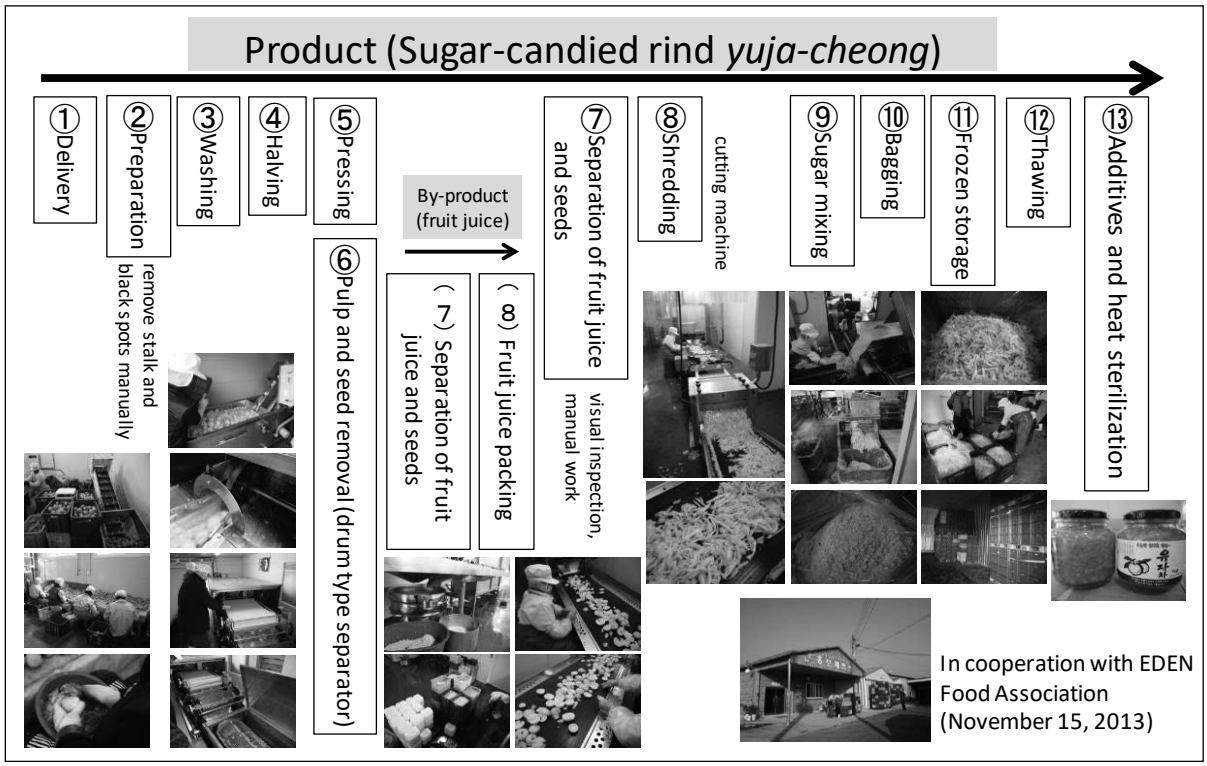

Figure 7 Yuzu Rind and Juice Processing in South Korea (Goheung County, South Jeolla Province)

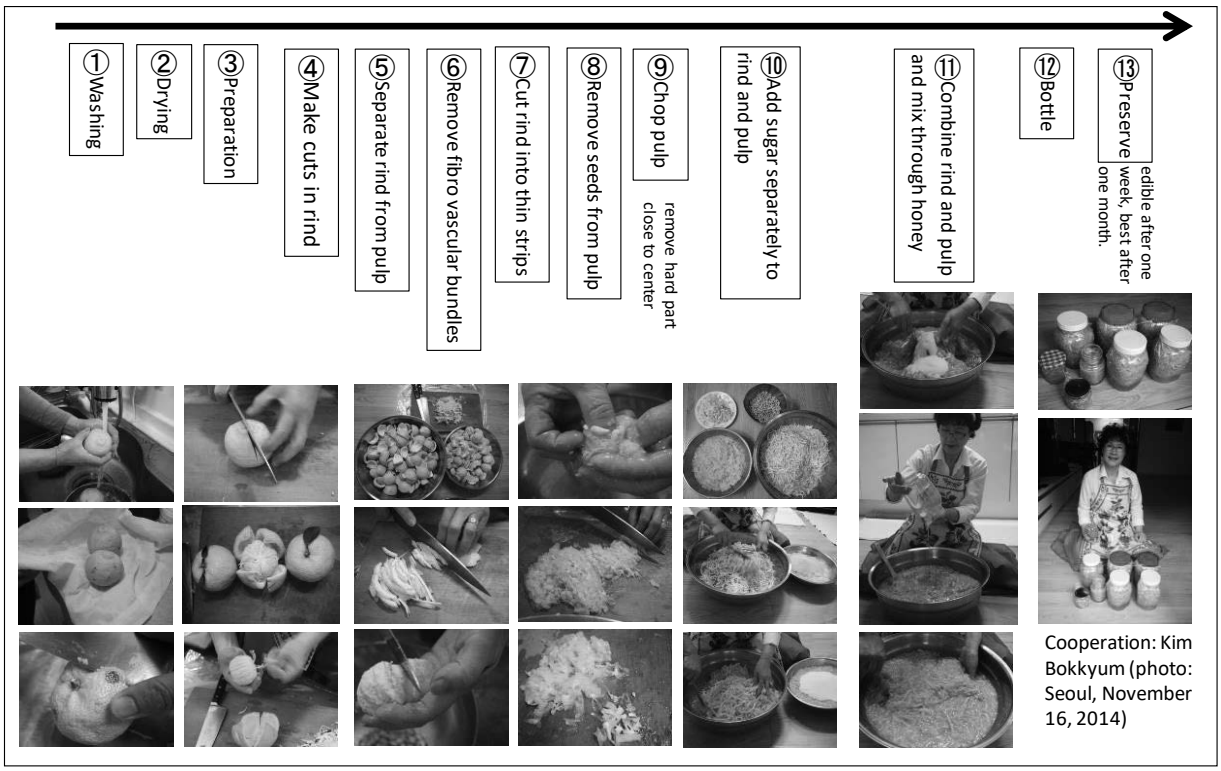

Figure 8 South Korean Homemade *Yuja-cheong* Recipe

3.3.2 Korean Yuja-cheong and Yuja-cha

Yuja-cheong unheated candied yuzu rind can be eaten about a week after production, but bottled *yuja-cheong* products are only available in small quantities even in yuzu growing areas. Bagged *yuja-cheong* made at processing facilities are stored frozen in containers and often distributed for business use as the raw material in other products, including *yuja-cha*. Because *yuja-cheong* is not heated, the color changes quickly at room temperature and it has a short expiration date. On the other hand, y*uja-cha* (yuzu tea; in this case referring just to the sweet paste before hot water is added) lasts a long time because of various additives to the base *yuja-cheong* and because it undergoes heat treatment. *Yuja-cha* processing facilities can be found all over Korea because they only need to purchase and process *yuja-cheong,* whereas facilities making y*uja-cheong* must be located in yuzu growing areas because their raw material is the fresh fruit. Figure 9 provides a comparison of the raw materials for *yuja-cha* and *yuja-cheong*.

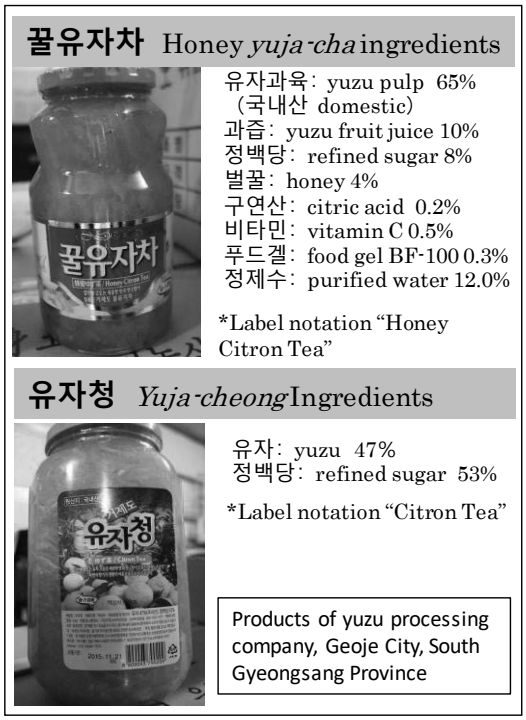

Figure 9 Differences in Raw Materials for Bottled *Yuja-cha* and *Yuja-cheong* Products

3.3.3 Yuja-cheong in Traditional Korean Confectionery – Yuja-ganjeong –

A Korean family showed us how to make yuzu-flavored *ssal-ganjeong* – traditional confectionery using ordinary rice (*ssal* means rice). It is often made for the Lunar New Year celebration using *yuja-cheong* made in November. The recipe, apparently learned from a cooking teacher 45 years ago, requires the ordinary rice to be boiled and dried a week prior to preparation. The rice which has been deep-fried and coated with sugar/honey is spread in a special thin wooden mold and cooled slightly and then quickly cut before completely hardening (Figure 10).

3.3.4 Main Japanese Processed Yuzu Goods – Yuzu Juice Production

i) Japanese Production Process (Kitakawa Village, Kochi Prefecture)

In Japan, the target product is yuzu juice, and the rind is a by-product. In order to obtain highly fragrant juice, whole yuzu fruit is pressed firmly thereby transferring the essential oil found in the oil glands of the flavedo into the juice. After the halved fruit is squeezed through a narrow opening in the press machine, the juice is passed through a sieve in two stages to remove seeds, flesh and cream, and the resulting juice is frozen at -30℃ for shipment. The juice is defrosted in portions as needed for use in various processed products.

The rind left after pressing is a by-product that is bagged and either discarded or frozen and stored for external secondary use (Figure 11).

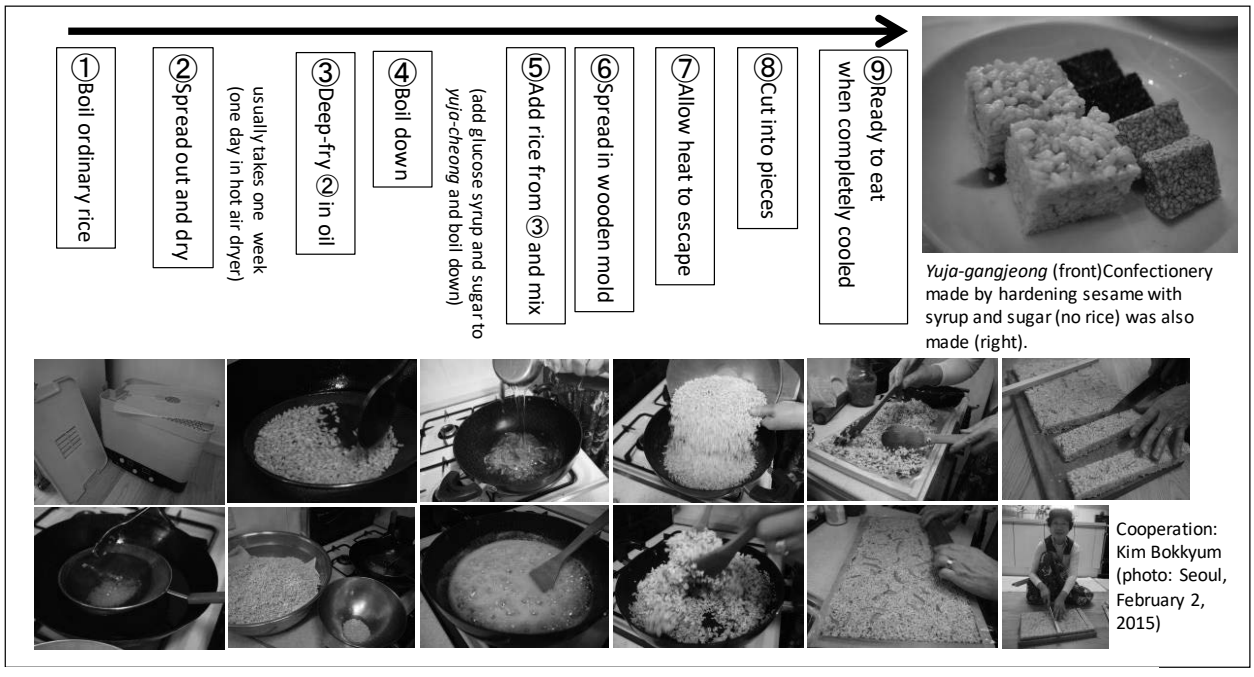

Figure 10 South Korean Homemade Traditional Confectionery (*Ssal-gangjeong*) Recipe

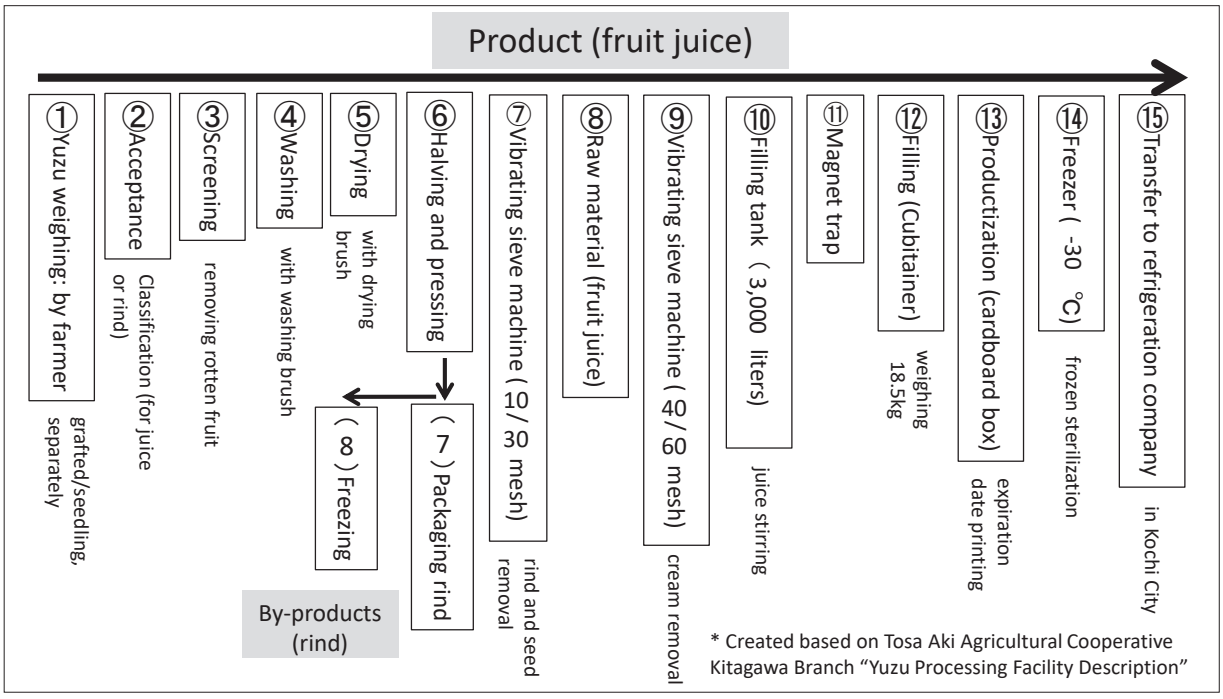

Figure 11 Yuzu Juice and Rind Processing in Japan (Aki County, Kochi Prefecture)

ii) Yuzu Farmer's Harvesting and Pressing Methods

When harvesting yuzu, utmost care must be taken to not damage the fruit in order to avoid spoilage of the juice. The fruit is picked by hand before it falls to the ground. These days, more and more farmers ship whole fruit to juice factories, but in the past it was common for yuzu farmers to press their own yuzu. As shown in Figure 12, specially designed wooden juice presses are made locally in the growing area, but at present, there is only one woodworker in neighboring Umajimura village who makes juice presses. Some farmers are even said to take their juice presses out into the orchards with them to press immediately after harvesting. In those cases, the rind is discarded in the orchard.

The harvesting method in Geoje, South Korea, in contrast, involved collecting yuzu fruit cut from the trees and dropped on the ground, and putting them in containers (Figure 13). Because the yuzu are harvested for rind, not juice, and because the rind is candied in an equal amount of sugar, the feeling is there is no need to worry about a few blemishes.

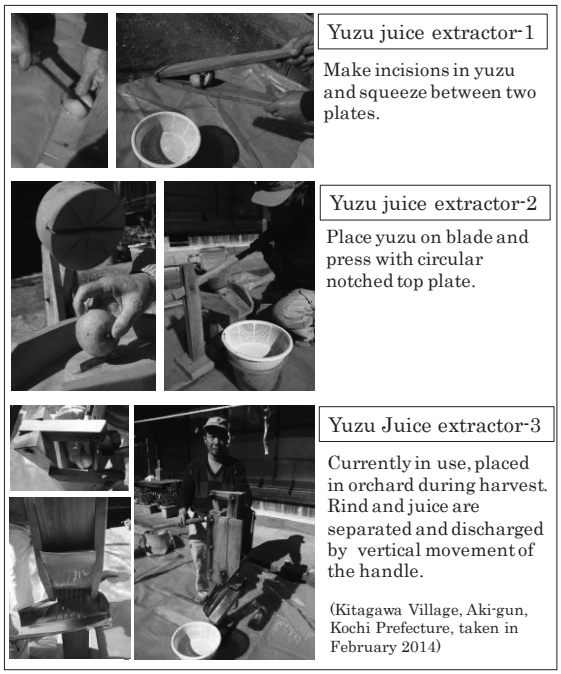

Figure 12 Hand-press Juice Extractor at Yuzu Farm

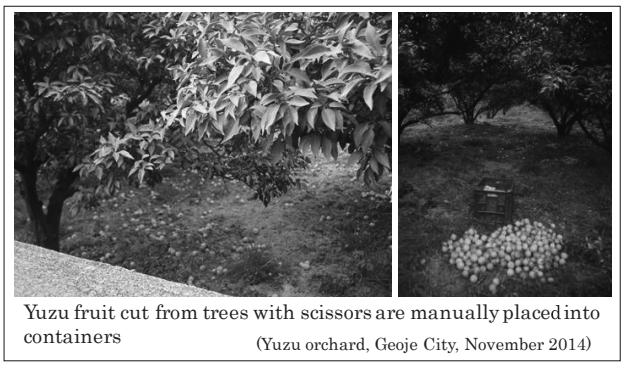

Figure 13 Yuzu Harvesting in South Korea

3.4 New Yuzu Trends in Japan and South Korea

3.4.1 Yuja-cheong in Western Cuisine and Confectionery and New Applications for Juice and Raw Rind

i) In Dressings and Cakes

Yuzu dressing represents a common modern use for yuzu in South Korea. *Yuja-cheong* was found in salads at Korean restaurants and in bottled dressings sold at department stores. The key difference is that in South Korea, *yuja-cheong* is used to flavor and sweeten the dressing, whereas in Japan, yuzu juice is used as a substitute for vinegar.

At a department store in South Korea, a Western-style cake shop was selling chiffon cakes decorated with *yuja-cheong*, and yuzu macarons were becoming standard fare at French confectionery stores. In all cases, the ingredients were thought to be those first processed by candying or heating during the yuzu harvest season for secondary use throughout the year.

ii) Use of Yuzu Juice in South Korea

In recent years, there has been a movement to use yuzu juice in South Korea. The ongoing development of various applications of yuzu juice, which until now was simply a by-product of *yuja-cheong* production, were confirmed through regular visits to South Korea, and included yuzu syrup to be diluted to make yuzu beverages, yuzu juice, and yuzu liquor.

In November 2014, when I visited the Goheung County Agricultural Cooperative Facility Factory, the person in charge offered me a taste of yuzu syrup. It was a liquid made of sweetened yuzu juice and honey, sufficiently sweet and delicious to me, but I will never forget how the factory manager and town office staff member offered up the same grimace, rating the juice too sour.

In Japan, the use of ponzu sauces containing highly acidic citrus juice is widespread, and the variety of those containing yuzu has increased in recent years. In South Korea, soy sauce called *ganjang* is combined with vinegar to make *cho-ganjang*, which is frequently served as a dipping sauce for *buchimgae* Korean-style savory pancakes. However, it is not common in South Korea to mix *ganjang* with citrus juices to make ponzu-style sauces. A major South Korean seasoning company is developing ponzu as a signature Japanese seasoning, but as of 2015 only one type of yuzu ponzu has been identified.

Yuzu juice, not found in 2013, was identified at a convenience store after autumn 2014. Since then, yuzu juice has become a standard product, with glass and plastic bottle products becoming more common. Figure 14 shows yuzu juice varieties purchased in Seoul, Busan and other cities.

① Yuzu *Ponzu* (Seoul, 2014)
② Yuzu Syrup (Seoul, 2014)
③ Various yuzu juices (Seoul,Goheung County, 2014-2015)

Figure 14 Bottled Yuzu Juice Obtained in South Korea

iii) Raw Rind Applications in South Korea

A chocolate shop in Seoul opened by a young female Korean chocolatier in July 2014 sells yuzu chocolate (Figure 15). Here, raw yellow yuzu rind is grated and frozen during the yuzu season for use throughout the year in a mixture with ganache. Awareness of yuzu macarons made by a French pâtissier in charge of product development at a Western-style cake shop in Seoul got the chocolatier thinking that there must be a way to use yuzu besides the traditional Korean application of *yuja-cheong*. Her hint appears to have come from grated lemon zest, which can be found in Western foods and sweets, because she had not considered the equivalent Japanese technique for sprinkling raw yuzu rind called *furi-yuzu*.

When yuzu is in season, the outer rind is grated and frozen to store. It is mixed with fresh cream as needed to make a ganache. Yuzu chocolate is offered year-round until the stock of frozen yuzu rind runs out. (Seoul, November 2015)

Figure 15 Yuzu Method at South Korean Specialty Chocolate Store

3.4.2 Japanese Yuzu Tea Production and Usage

i) Use of Korean Yuja-cha in Japan

In recent years, products labeled "*yuzu-cha*" have begun to appear in Japan. South Korean *yuja-cha* (*yuzu-cha,* yuzu tea) is classified into two types. One is prepared by pouring hot water over sugar-candied *yuja-cheong*, and the other is prepared by pouring hot water into *yuja-cha* – a sweet paste of pasteurized *yuja-cheong* with additives that is the base of yuzu tea. The Japanese word "*yuzu-cha*" includes many types in a much broader sense. For the purposes of this paper, Korean-style yuzu tea refers to South Korean *yuzu-cha*.

In recent years, private exchanges have flourished, and food information is regularly shared between Japan and South Korea, leading to mixing of ingredients and mutual influence on the use of ingredients and eating styles. One prominent example is Korean-made Korean-style yuzu tea and the increasing use of it.

In Tsuruhashi, Osaka, where there are many Korean food stores, a wide selection of Korean-style yuzu tea drinks and shaved ice items can be found on coffee shop menus. These are clearly Korean-style items reflective of the locale. But there are also examples in quintessentially Japanese places where Korean-style yuzu tea is served without playing on its connection to Korean-style sweets. Yuzu shaved ice was listed as one Japanese-style shaved ice variety at a Japanese cafe in Arashiyama, Kyoto; and yuzu tea can be found on the menus of nationwide coffeehouse chains (Figure 16). Korean-style yuzu tea may over time come to be perceived as a Japanese product. I think it will be important going forward to investigate changing trends in distribution of yuzu products as well as the degree of recognition and consumption rates among general consumers.

As an ingredient

Kyoto shaved ice with specially selected yuzu using bottled *yuzu-cha* , Japanese café (Arashiyama, Kyoto, August 2015)

Popularization as a beverage

Hot water is added to bottled yuzu tea, coffeehouse chain (Shibuya, Tokyo, January 2016)

Unheated candied yuzu

A product made with only yuzu and rock sugar, sold on appeal of being an unheated product with brand name "raw *yuzu-cha*" (Kochi Airport stand, January 2016)

Figure 16 Korean-style Yuzu Tea in Japan

ii) Classification of Japanese Yuzu Tea

To identify the kinds of yuzu-flavored tea drinks, other than Korean-style yuzu tea, available in Japan, I searched major online retailer amazon.co.jp using Japanese keywords for "yuzu tea" and "domestically produced". Of course, it only offers a snapshot of one point in time, namely January 2016, but the search results are introduced here for reference (Table 4).

While most were Korean-style yuzu tea products, there were also various flavored tea products made by blending green tea or black tea leaves with dried yuzu rind.

One such commercial flavored tea product blending yuzu rind from Jeju Island with green tea leaves was identified in South Korea in 2014. In Japan, some of the product names specified whether the green tea was regular, *sencha* (middle-grade), or roasted tea. In addition, there were several flavored yuzu tea varieties made by blending yuzu with Japanese black tea.

Because Japan has its own Japanese tea culture using tea leaves, in addition to the uptake of Korean-style sweet yuzu tea, we can also see the development of innovative products made with tea leaves. Separately, the technique of blending green tea with various herbs and dried fruits is thought to have entered Japan from Europe, where flavored teas are common. Interestingly, in Japan, we also found tea made only from yuzu seeds and a flavored tea containing yuzu flowers.

Table 4 Classification of Japanese-made Yuzu Tea Varieties

Yuzu tea		
	Paste	30
	Powder	6
Yuzu tea (with tea leaves)		
	Green tea blend *1	9
	Black tea blend	6
Other yuzu-flavored tea *2		3
Total		54

Total of 153 items returned in search on Amazon.co.jp for "*yuzu cha*" (as of January 7, 2016), after removing duplicates and non-tea items.

* 1 Breakdown of tea leaves: green tea 4, sencha 4, roasted tea 1

* 2 Tea breakdown: Blend of flower and health food tea 1, only seed 1, rind and herbal tea 1

4. CONSIDERATION

Through examples of yuzu usage in Japan and South Korea, I have outlined the key differences in usage between the two countries and have included examples that show how distinctions are gradually disappearing. Traditionally in Korea, yuzu has been processed into sugar- or honey-candied *yuja-cheong* for secondary use, whereas in Japan, yuzu fruit juice and raw rind have been the key products. However, recent trends show increasing use of Korean-style yuzu tea in Japan and increasing use of yuzu fruit juice in Korea.

When each country uses yuzu to add a local twist to newly introduced Western dishes or confectioneries, the difference in traditional yuzu usage becomes very clear. One good example is yuzu dressing. While the common feature of yuzu use in Japan and South Korea is to enjoy the fragrance, the fundamental difference is that South Korea uses *yuja-cheong* to add sweetness and Japan uses yuzu juice to add acidity.

Saga-Mizuo in Kyoto City has long been known as a yuzu growing region, and it was there I had the chance to drink yuzu tea at a specialty yuzu restaurant. A simple drink made by cutting raw yuzu fruit in half and adding sugar and hot water was called yuzu tea. Although it is similar to hot lemonade, this method of serving yuzu tea using raw yuzu seems to embody the Japanese preference for raw foods.

Food cultures interact and become blended, but it takes a significant amount of time for fundamental differences to change.

A researcher specializing in citrus fruits with extensive experience visiting Japan, South Korea, and China, suggested there may be differences between South Korea and Japan in preferences for sour citrus flavors. With a regular diet of sour kimchi that has undergone lactic acid fermentation, South Koreans are thought to be accustomed to sour food in general. However, there seems to be some divergence in tolerance for the sourness of citrus fruits, high in citric acid, and the preference for sweetness between Japanese and South Koreans. If so, the development of fresh yuzu juice usage in South Korea will be affected by taste preferences cultivated over many years. Citrus juice preferences in Japan and South Korea is best covered as a separate research topic.

5. CONCLUSION

Full-fledged yuzu cultivation has been undertaken in Japan and Korea for the last 40 to 50 years. We can identify differences in traditional applications of yuzu: South Korea has typically processed yuzu into the sugar- or honey-candied *yuja-cheong* for secondary use, whereas Japan has typically used the juice and raw rind of fresh yuzu fruit. Despite these fundamental differences, mutual influences seem to be leading to the emergence of new and different uses for yuzu in both countries. With further globalization and ever-increasing cross-cultural exchanges, there is a need for qualitative and quantitative fixed-point observations of these changes in yuzu usage.

6. ACKNOWLEDGMENTS

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再録　総説

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米飯の初期老化を数値化および視覚化する多面的評価法

大田原美保
東京聖栄大学健康栄養学部

要旨

澱粉性食品である米飯は，糊化温度以下の保存，特に冷蔵においてアミロースやアミロペクチン分子鎖の再会合により外観やテクスチャーなどが急速に変化して食味が低下する。このような現象を“米飯の老化”といい，飯のおいしさへの要求水準が高いわが国では，老化の制御は重要な課題である。中食・外食産業において，白飯・すし飯・おにぎり等の米飯類は冷蔵を要する場合が多く，品質評価と管理ではその間の食味変化を客観的に捉える方法が重要となる。著者らは冷蔵 24 時間程度までの米飯の老化（以下，初期老化と称す）について，官能評価との対応性を考慮した客観的評価方法の研究を行ってきた。さらにその過程で，物性測定以外の評価法として，米飯粒内部の変化を色や画像解析で捉える新たな評価方法を見出した。著者らが一連の研究で明らかにした米飯の初期老化の評価法を以下に示す。

1. 官能評価で捉える“米飯の老化感”を，物性測定値の硬さと粘りを説明変数とする重回帰式によって予測して評価する方法。この方法によって，人が食べた時の感覚に対応する米飯の老化の評価が可能となった。

2. 米飯の物性（硬さ，粘り）変化に速度論的解析を適用し，米飯の老化による物性の変化速度を評価する方法。変化速度の比較によって，米飯の炊飯直後の状態の違いに影響されず，各試料の老化速度の評価が可能となった。さらに，速度論的解析の結果を用いて，米飯の硬さと粘りの両方の変化を考慮した食味低下のシミュレーションを示すことができた。

3. 米飯 1 粒を薄く圧縮した圧縮米飯粒の色と画像解析による米飯の老化の新規評価方法。この方法は米飯の老化を米粒内輝度分布として視覚的に示すことができ，かつ老化感に対応しうる指標によって米飯の老化状態を数量的にも示すことができる有用な評価方法であることが示された。

本研究の特徴は，米飯の初期老化に着目し，官能評価との対応性を考慮した客観的評価法を検討したことである。従来行われてきた物性測定値による経験的な老化の判断や澱粉の老化の把握のみでなく，速度論的解析を取り入れた老化速度の分析や画像解析による米飯の老化の視覚化と数値化など，新たな視点から初期老化を多面的に捉える評価法を示した。これらの結果は米飯の品質管理や制御に資する有用な知見となると考えている。

再録　報文

安全工学　58巻5号310~314（2019）

コーヒーの成分と発がん抑制作用

木村俊博*、伏脇裕一*
*東京聖栄大学健康栄養学部

要旨

コーヒーは昔から薬として使用され、今日では飲料として多くの人に愛されている。

コーヒーと聞くとカフェインが真っ先に浮かぶ物質である。カフェインには脳の活動の活性化、思考力や集中力の上昇、疲労感の軽減などの作用があることが知られている。その他にクロロゲン酸、フェルラ酸、トリゴネリン等の体に良い影響をもたらす物質も存在する。これらの物質には、発がんリスクの低下に係わっていると考えられている。

近年の研究では、コーヒーを飲む人の肝がんや子宮体がんの発生率がコーヒーを飲まない人と比べてかなり減少し、発がんリスクを下げることが報告されている。

コーヒーは漢方と違い、発症してから飲むのでは薬理的な効果は発揮されない。しかし、がん予防だからといっても限度があり、適度に嗜好品として飲むことが重要である。

再録　報文

BMC Medical Genetics (2019) 20:192.

COL5A1 rs12722 polymorphism is not associated with passive muscle stiffness and sports-related muscle injury in Japanese athletes

Eri Miyamoto-Mikami[1,2], Naokazu Miyamoto[3], Hiroshi Kumagai[1,4], Kosuke Hirata[4,5], Naoki Kikuchi[6], Hirofumi Zempo[1,7], Noriko Kimura[8], Nobuhiro Kamiya[9], Hiroaki Kanehisa[10], Hisashi Naito[1,2,3] and Noriyuki Fuku[1,2,3]

[1]Institute of Health and Sports Science & Medicine, Juntendo University. [2]Juntendo Advanced Research Institute for Health Science, Juntendo University. [3]Graduate School of Health and Sports Science, Juntendo University. [4]Research Fellow of Japanese Society for the Promotion of Science. [5]Graduate School of Engineering and Science, Shibaura Institute of Technology. [6]Department of Training Science, Nippon Sport Science University. [7]Faculty of Health and Nutrition, Tokyo Seiei College. [8]Graduate School of Sport and Exercise Sciences, Osaka University of Health and Sport Sciences. [9]Faculty of Budo and Sport Studies, Tenri University. [10]Faculty of Sport and Health Science, Ritsumeikan University.

Abstract

Background: Poor joint flexibility has been repeatedly proposed as a risk factor for muscle injury. The C-to-T polymorphism (rs12722) in the 3′ -untranslated region of the collagen type V α1 chain gene (COL5A1) is reportedly associated with joint flexibility. Flexibility of a normal joint is largely determined by passive muscle stiffness, which is influenced by intramuscular collagenous connective tissues including type V collagen. The present study aimed to test the hypothesis that the COL5A1 rs12722 polymorphism influences joint flexibility via passive muscle stiffness, and is accordingly associated with the incidence of muscle injury.

Methods: In Study 1, we examined whether the rs12722 polymorphism is associated with joint flexibility and passive muscle stiffness in 363 healthy young adults. Joint flexibility was evaluated by passive straight-leg-raise and sit-and-reach tests, and passive muscle stiffness was measured using ultrasound shear wave elastography. In Study 2, the association of the rs12722 polymorphism with sports-related muscle injury was assessed in 1559 Japanese athletes. Muscle injury history and severity were assessed by a questionnaire. In both Study 1 and Study 2, the rs12722 C-to-T polymorphism in the COL5A1 was determined using the TaqMan SNP Genotyping Assay.

Results: Study 1 revealed that the rs12722 polymorphism had no significant effect on range of motion in passive straight-leg-raise and sit-and-reach tests. Furthermore, there was no significant difference in passive muscle stiffness of the hamstring among the rs12722 genotypes. In Study 2, rs12722 genotype frequencies did not differ between the muscle injury and no muscle injury groups. Moreover, no association was observed between rs12722 polymorphism and severity of muscle injury.

Conclusions: The present study does not support the view that COL5A1 rs12722 polymorphism has a role as a risk factor for sports-related muscle injury, or that it is a determinant for passive muscle stiffness in a Japanese population.

再録　報文

Med Sci Sports Exerc. 2019;51(1):19-26.

ESR1 rs2234693 Polymorphism Is Associated with Muscle Injury and Muscle Stiffness.

Hiroshi Kumagai[1,2], Eri Miyamoto-Mikami[1,3], Kosuke Hirata[3], Naoki Kikuchi[4], Nobuhiro Kamiya[5], Seigo Hoshikawa[1,6], Hirofumi Zempo[7], Hisashi Naito[1], Naokazu Miyamoto[3], and Noriyuki Fuku[1]

[1]Graduate School of Health and Sports Science, Juntendo University. [2]Research Fellow of Japanese Society for the Promotion of Science. [3]Department of Sports and Life Science, National Institute of Fitness and Sports in Kanoya. [4]Department of Training Science, Nippon Sport Science University. [5]Faculty of Budo and Sport Studies, Tenri University. [6]Edogawa University. [7]Faculty of Health and Nutrition, Tokyo Seiei College.

Abstract

Purpose: Muscle injury is the most common sports injury. Muscle stiffness, a risk factor for muscle injury, is lower in females than in males, implying that sex-related genetic polymorphisms influence muscle injury associated with muscle stiffness. The present study aimed to clarify the associations between two genetic polymorphisms (rs2234693 and rs9340799) in the estrogen receptor 1 gene (ESR1) and muscle injury or muscle stiffness.

Methods: In study 1, a questionnaire was used to assess the muscle injury history of 1311 Japanese top-level athletes. In study 2, stiffness of the hamstring muscles was assessed using ultrasound shear wave elastography in 261 physically active young adults. In both studies, rs2234693 C/T and rs9340799 G/A polymorphisms in the ESR1 were analyzed using the TaqMan SNP Genotyping Assay.

Results: In study 1, genotype frequencies for ESR1 rs2234693 C/T were significantly different between the injured and noninjured groups in a C-allele dominant (CC + CT vs TT: odds ratio, 0.62; 95%confidence interval, 0.43–0.91) and additive (CC vs CT vs TT: odds ratio, 0.70; 95% confidence interval, 0.53–0.91) model in all athletes. In study 2, hamstring muscle stiffness was lower in subjects with the CC + CT genotype than in thosewith the TT genotype; a significant linear trend (CC G CT G TT)was found ($r = 0.135$, $P = 0.029$). In contrast, no associations were observed between ESR1 rs9340799 G/A and muscle injury or stiffness.

Conclusions: Our results suggest that the ESR1 rs2234693 C allele, in contrast to the T allele, provides protection against muscle injury by lowering muscle stiffness.

再録　口頭発表

日本調理科学会　2019 年度大会

調味料を添加して炊飯した米飯の圧縮米飯粒を用いた老化評価

大田原美保[1]　北原茉実[2]　大石恭子[3]　香西みどり[2]

[1]東京聖栄大学　[2]お茶の水女子大学　[3]和洋女子大学

要旨

【目的】演者らは炊飯後冷蔵 24 時間程度までの米飯の初期老化に着目し，冷蔵後の飯粒を厚さ 0.1mm に圧縮した試料（圧縮米飯粒）を作成し，色測定と画像解析による初期老化の評価法を考案した。4 品種の米飯では，圧縮米飯粒の色や画像解析値と官能評価及び物性測定値には高い相関が認められた[1)]。本研究ではこの評価法の拡大適用を目的として，調味米飯試料の初期老化の評価を行った。

【方法】洗米・浸漬後，加熱直前に砂糖，食塩，醤油，食酢，合わせ酢を添加して炊飯し，その後米飯を 4℃で 0-24 時間まで冷蔵して試料米飯とした。これを一粒ずつスライドガラス上に置き，カバーガラスの上から 0.1mm に圧縮して圧縮米飯粒プレパラートを作成してその色測定（L*）及び顕微鏡観察による画像の輝度値を解析した。官能評価による米飯の老化感，物性測定（表層及び全体の硬さ,粘り）により試料米飯の老化の程度を把握した。

【結果】物性測定では，食塩添加米飯の冷蔵 14 時間は同時間の白飯よりも全体硬さが大きい傾向を示した。食酢および合わせ酢添加米飯の粘りや付着性は炊飯直後から高く冷蔵後も高値を示し，表層及び全体硬さの冷蔵による増大は小さかった。圧縮米飯粒の L*や画像解析値は食塩添加米飯の冷蔵 14 時間が他試料よりも老化が進んでいることを示し，食酢や合わせ酢添加米飯の老化抑制傾向を示していた。官能評価において，食酢及び合わせ酢添加米飯の老化感は冷蔵後も他試料より低かった。食塩添加米飯は物性や圧縮米飯粒測定では白飯よりも老化傾向にあったが，老化感は白飯と同程度であり，官能で捉える老化には味の影響が示唆された。

1）大田原ら(2018)，日本食品科学工学会誌, 65, 170-182

再録　口頭発表

日本食生活学会　第57回大会　一般公演（B4）2018年10月27日（中村学園大学）

低タンパク質摂取時による飼料中リン量および脂肪量がラットの腎臓石灰化に及ぼす影響について

○大塚静子[1)]、青山美子[2)]、北野隆雄、阿左美章治[3)]

[1)]東京聖栄大学・健康・管理、[2)](株)天然素材探索研究所、[3)]東京聖栄大学付属調理師専門学校

要旨

【目的】高齢化社会において栄養素の過不足摂取が問題となり、特に低タンパク質、高脂肪、高リンの摂取が危惧されている。本研究では、AIN-76 精製飼料を基本にした低タンパク質、高脂肪食を幼若期ラットに与えた。また、飼料中リン量を減じた場合の腎臓中カルシウム(Ca)沈着の動向など生体成分への影響について検討した。

【方法】生後 4 週令の Fischer 系雌ラットを 40 日間飼育した。試験群は AIN-76 精製飼料の組成を基本とし、タンパク質 10%、Ca 量 0.52%、P 量 0.40%の標準 P 飼料（NP 群）と P 量 0.28%の低 P 飼料（LP 群）の 2 つの実験群を設けた。脂肪量はそれぞれ 5,10,20%に調整した。

【結果】飼料摂取量は NP 群と LP 群のいずれも脂肪量の増加に伴い低下した。腎臓中 Ca 量は LP 群で低値を示し、飼料中 P 量と脂肪量の影響が認められた。腎臓石灰化の程度は NP 群で 201～400、LP 群で 21～100 と飼料中 P 量の低下により腎臓石灰化の程度は軽減された。また、NP 群、LP 群いずれも脂肪量の増加に伴い、腎臓石灰化は亢進し脂肪量の影響が認められた。P 摂取量を減らすことは腎臓中 Ca 量や腎臓石灰化の軽減に有効であることが示唆された。

再録　ポスター発表

日本調理科学会　2019年度大会（令和元年8月27日）

ごぼう茶の抗酸化活性

○片山佳子*　　小林壮*

*東京聖栄大学健康栄養学部

要旨

【目的】ごぼうには、ポリフェノールの一種であるクロロゲン酸や食物繊維が含まれており、抗酸化作用、悪玉コレステロールの排出や血糖値上昇を抑制する働きがある。ごぼうは調理をする際に、えぐみや泥臭さをなくすために水にさらし、あく抜きをするのが一般的である。しかし、このあく抜きによって機能性成分である水溶性のポリフェノールやイヌリンが溶出し減少してしまう。そこで、あく抜き工程がなく製造されているごぼう茶に着目し、市販品 3 種のポリフェノール量の測定を行うとともに抗酸化活性測定を行い比較検討することを目的とした。

【方法】市販品の A 社(国産)、B 社(国産)、C 社(中国産)のごぼう茶を 20℃では 120 分間、沸騰させた熱水では 5、20、40、60 分間と抽出時間を変えてこれらを試料溶液とした。ポリフェノール量の測定は Folin-Ciocalteu 法にて行った。抗酸化活性はラジカル消去能を DPPH 法で測定した。また DPPH ラジカル消去能は Trolox 相当量として算出した。

【結果】ポリフェノール量は A 社、B 社、C 社の順に高かった。抗酸化活性は各試料とも 20℃ と熱水とでは熱水抽出の方が高く、また抽出時間が長いほど高い活性を示し、A 社が B 社、C 社よりも高い値を示した。そこで、ポリフェノール量と抗酸化活性の関係を見たところ、両者には高い正の相関関係が認められ、ごぼう茶の抗酸化活性はポリフェノール由来によるものであることが示唆された。また今回の結果からごぼう茶のポリフェノール量や抗酸化活性には、ごぼうの原産地や種類の違いによって差異があることが明らかとなった。

東京聖栄大学紀要投稿要領

（投稿者の資格）

１、東京聖栄大学紀要(以下、本紀要という。)への投稿者は本学教育職員に限る。ただし、本学内外の共同研究者は、本学教育職員との連名とする。

（論文の種類）

２、掲載論文の種類は和文または欧文で、次の基準によるものとする。抄録以外は未発表のものに限る。

１）総説 Review　学術的な研究分野をまとめたもの。

２）原著論文 Articles　独創的な研究論文の内容を備え、学術的な価値があると認められたもの。 その掲載量は印刷面10頁以内とする。超過した場合は、超過分に関わる実費を徴収する。

３）短報 Note　原著論文に準ずる価値のあるもの。その掲載量は印刷面で6頁以内とする。

４）資料 Research Data　調査、実験データなどで、学術上有益と認められたもの。その掲載量は印刷面で10頁以内とする。

５）抄録 Abstract　他誌に発表した論文の要旨を著者がまとめたもの。

６）翻訳 Translation　既に発表された論文を翻訳したもの。

７）解説 Interpretation　学術的な研究分野をまとめたもの。

８）再録 Re-printing

（投稿原稿の取り扱い）

３、本紀要に投稿された原稿（総説を除く）の取り扱いはつぎの通りとする。

１）投稿は紀要編集委員会(以下、委員会という。)宛とし、提出された日を受付日とする。ただし、原稿は本規定に従い内容体裁が整った完成原稿でなければならない。

２）受付された原稿は委員会の指名する２名以上の審査員により審査する。

３）審査員からの審査報告書、および委員会からの指摘事項があった場合は委員会を通して投稿者に伝える。投稿者は指摘事項について検討し、所定の期日までに委員会に再提出しなければならない。期日までに再提出しない場合は投稿を取り下げたものとする。

４）審査の結果に基づき委員会で掲載の可否を決定する。掲載が許可された場合はその日をもって受理日とする。

５）掲載が許可された原稿は委員会が校正以外は変更してはならない。

（掲載原稿の取扱い）

本誌に掲載が許可された原稿の取扱いは、次の通りとする。

１）掲載原稿の著作権は、委員会に帰属する。

２）別刷は、50部までは無償とし、規定を越えた分は実費を徴収する。

東京聖栄大学紀要執筆要領

（投稿時の提出物）

1．投稿する研究論文は東京聖栄大学紀要(以下、本紀要という。)用テンプレートを用いてwordで作成した印字原稿に、電子ファイルを添えて紀要編集委員会(以下、委員会という。)に提出する。

2．テンプレートは本紀要ホームページから入手すること。
テンプレートは原稿作成上の注意書きになっているので原稿作成前に良く読むこと。

（原稿の執筆要領）

3．原稿の書式は和文の場合は、28字×43行×2段を１ページとする。欧文原稿では8.2cm×43行×2段を１ページとする。

4．本文の前に論文題名、著者名、アブストラクト、（原稿受付日、原稿受理日）　　を記入する。

5．アブストラクトは英文とする。

6．本文は明朝体とし、緒言、実験方法、実験結果、考察（実験結果と考察は同じ項目としても良い）、要約、参考文献の順に記述する。

7．参考文献はアブストラクト、本文を通し、記載順に番号をふり、必要とする箇所の肩にアラビア数字を片カッコをつけて記入する。

8．第１ページ目の下部にはキーワードを５語程度記入する。

9．章、節はゴシック体とし、以下のように記すこととする。

大見出しは　１．２．３．・・・・・・・

中見出しは 1.1　1.2　1.3 ・・・・・・・

小見出しは 1.1.1　 1.1.2　 1.1.3・・・・・・・・・・

小見出しにさらに項を設ける場合には(1)　(2)　(3)・・・・・・

つぎはアルファベットで、a)　b)　c)・・・・・・・・

10. 英文の場合は、大見出しは各単語の頭文字を大文字とし、中見出し以下は第１文字のみ大文字とする。

11. 図、表、写真は英文表記とし本文中に組み込み、**Figure 1、 Table 1、 Photo 1**のように図表番号を記し、ボールド体とする。

12. 参考文献は本文末にまとめて掲載する。記載は、著者名、論文名、雑誌名、巻、号、ページ（最初と終わり）、発行年の順とする。
成書の場合は著者名、書名、引用ページ、出版社名、発行年の順に記載する。

東京聖栄大学紀要審査基準

（審査の対象）

１．審査の対象とする原稿は東京聖栄大学投稿要領２に定める原著論文、短報、および資料とする。

（査読者）

２．査読者は２名以上とし、学内外から紀要編集委員会(以下、委員会という。)によって選出される。

３．論文の内容・表現はすべて執筆者が責を負うものとする。

４．査読者の名は執筆者に秘すものとする。

（審査の方法）

５．査読者は審査結果を以下のように判定し、審査用紙に、修正要求、参考意見等を添えて委員会に返送する。

ａ）無修正で掲載可

ｂ）修正後に掲載可

ｃ）修正後に再審査

ｄ）掲載不可

６．無修正で掲載可と判定された原稿については、審査評を確認して委員会が最終的に掲載を決定する。

７．修正後掲載可と判定された原稿については、委員会が査読者に代わって修正部分を確認し、修正が十分になされていると判断した場合は掲載を決定できる。修正が不十分と判断した場合は執筆者に修正を求めるか、査読者に再審査を要請することができる。

８．査読者が原稿の修正が必要と判断した場合、および掲載不可と判断した場合は委員会は審査評を添付して、原稿を執筆者に返却する。

９．修正後に再審査と判定された場合、修正後の再審査は、原則として、当初選任された査読者がこれに当たるものとする。

10．原著論文として投稿されたもので、査読者が、内容が原著論文としての基準には達していないが短報としての価値があると判断した場合は、審査用紙にその旨を明記し、委員会に報告する。

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